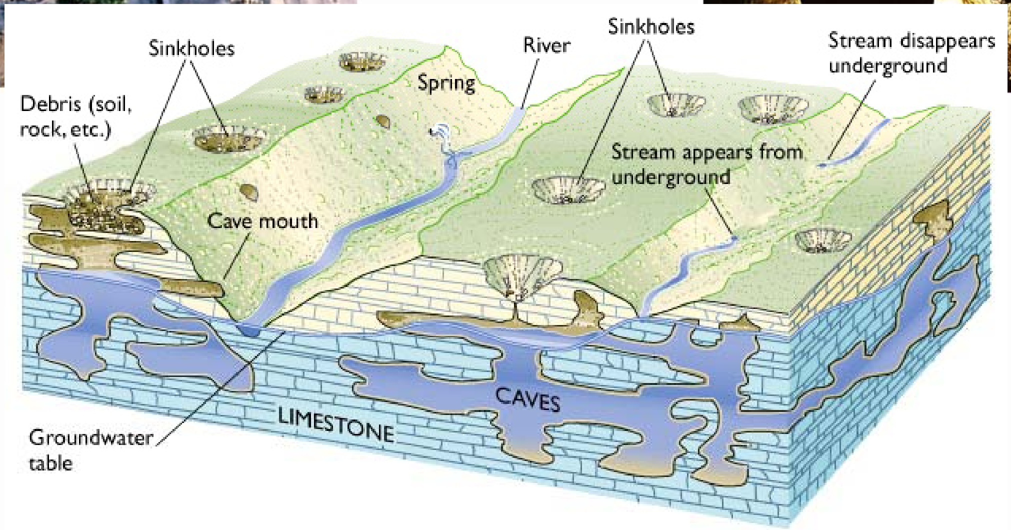
**TABLE 2.2** Principal processes of chemical weathering

| Name of process | Nature of process | Examples | Principal types of rock materials affected |
|---|---|---|---|
| Hydrolysis | Reaction between $H^+$ and $OH^-$ ions of water and the ions of silicate minerals, yielding soluble cations, silicic acid and clay minerals (if Al present) | $Mg_2SiO_4 + 4H_2O \rightarrow 2Mg^{+2} + 40H^- + H_4SiO_4$<br>(fosterite) (silicic acid)<br>$2KAlSi_3O_8 + 2H^+ + 9H_2O \rightarrow H_4Al_2Si_2O_9 + 4H_4SiO_4 + 2K^+$<br>(orthoclase) aq (kaolinite) (silicic acid) aq<br>$2NaAlSi_3O_8 + 2H^+ + 9H_2O \rightarrow H_4Al_2Si_2O_9 + 4H_4SiO_4 + 2Na^+$<br>(albite) aq (kaolinite) (silicic acid) | Silicate minerals |
| Hydration and dehydration | Gain or loss of water molecules from a mineral, resulting in formation of a new mineral | $CaSO_4 \cdot 2H_2O \rightleftharpoons CaSO_4 + 2H_2O$<br>(gypsum) (anhydrite)<br>$Fe_2O_3 + H_2O \rightleftharpoons 2FeOOH$<br>(hematite) (goethite) | Evaporites<br>Ferric oxides |
| Oxidation | Loss of an electron from an element (commonly Fe or Mn) in a mineral, resulting in the formation of oxides or, if water is present, hydroxides | $4FeSiO_3 + O_2 \rightarrow 2Fe_2O_3 + 4SiO_2$<br>(pyroxene) (hematite) (quartz)<br>$MnSiO_3 + \frac{1}{2}O_2 + 2H_2O \rightarrow MnO_2 + H_4SiO_4$<br>(rhodonite)<br>$2FeS_2 + 15/2\ O_2 + 4H_2O \rightarrow Fe_2O_3 + 4SO_4^{2-} + 8H^+$<br>(pyrite) (hematite) | Iron and manganese-bearing silicate minerals, sulfur |
| Solution | Dissolution of soluble minerals, commonly in the presence of $CO_2$, to yield cations and anions in solution | $H_2O + CO_2 + CaCO_3 \rightleftharpoons Ca^{2+} + 2HCO_3^-$ [carbonation]<br>(calcite) (bicarbonate)<br>$CaSO_4 \cdot 2H_2O \rightarrow Ca^{2+} + SO_4^{2-} + 2H_2O$ [direct solution]<br>(gypsum) | Carbonate rocks<br>Evaporites |
| Ion exchange | Exchange of ions, principally cations, between solutions and minerals | Na-clay + $H^+$ → H-clay + $Na^+$ | Clay minerals |
| Chelation | Bonding of metal ions to organic molecules having ring structures | Metal ions (cations) + chelating agent [excreted by lichens] → $H^+$ ions + chelate [in solution] | Silicate minerals |

- **Some minerals are congruently soluble in acidic water, leaving no residue**
  - **The most abundant is calcite: $CaCO_3 + H_2CO_3 = Ca^{2+} + 2HCO_3^-$ (the Tums reaction)**
  - **Effects of dissolution (and precipitation) of calcite can be dramatic, to say the least.**

Sinkhole

Speleothems


Sinkholes
Debris (soil, rock, etc.)
Spring
River
Sinkholes
Stream disappears underground
Stream appears from underground
Cave mouth
CAVES
LIMESTONE
Groundwater table

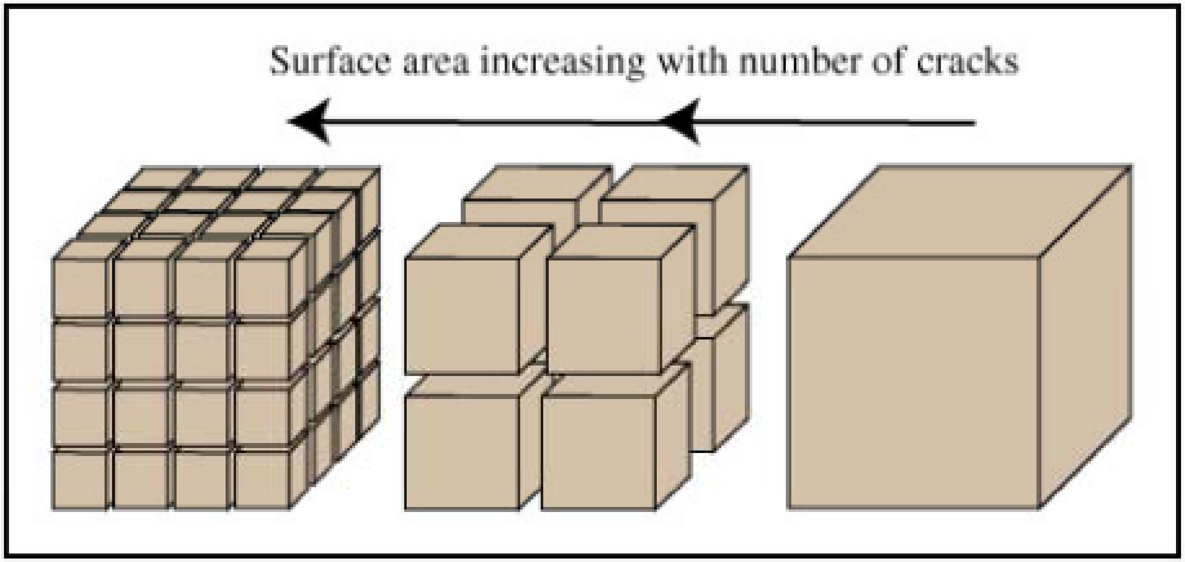
Karst terrain

BY : JHONNY

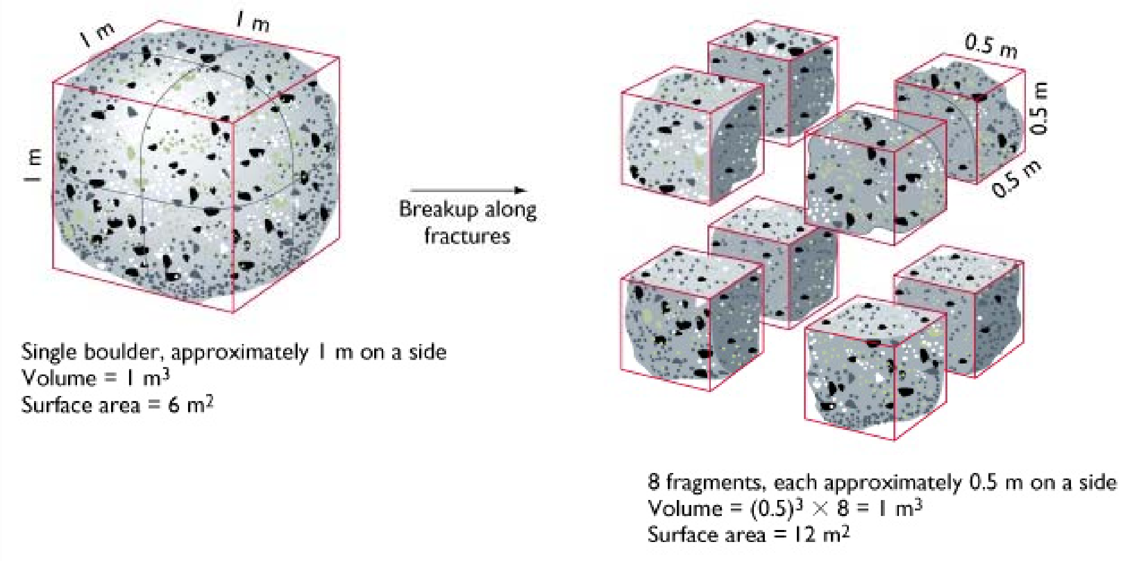
# Mechanical

When physical and chemical weathering operate together ➔ mechanical weathering

➔ more cracks (fractures) ➔ surface area>>>

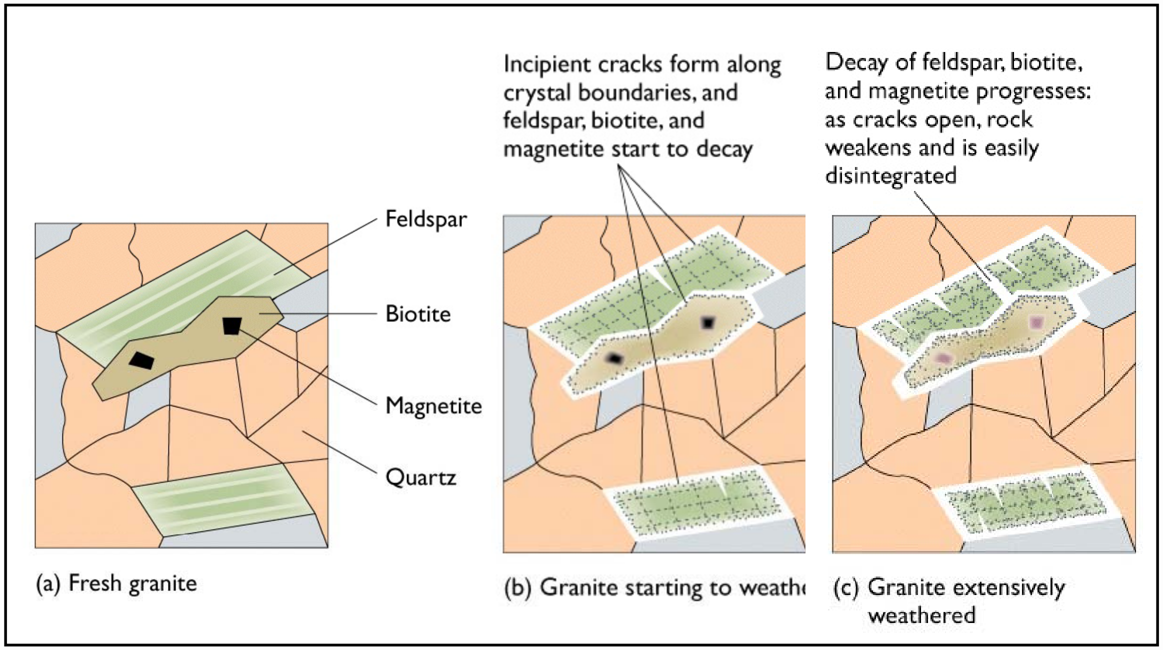


- Physical weathering and chemical weathering generally proceed in parallel in most environments.
- Physical and chemical weathering promote one another:
  - Formation of cracks by physical weathering increases reactive surface area, promoting chemical weathering.
  - Chemical weathering replaces intact interlocking minerals with weak clays or void space, making the rock easier to physically disaggregate, promoting physical weathering

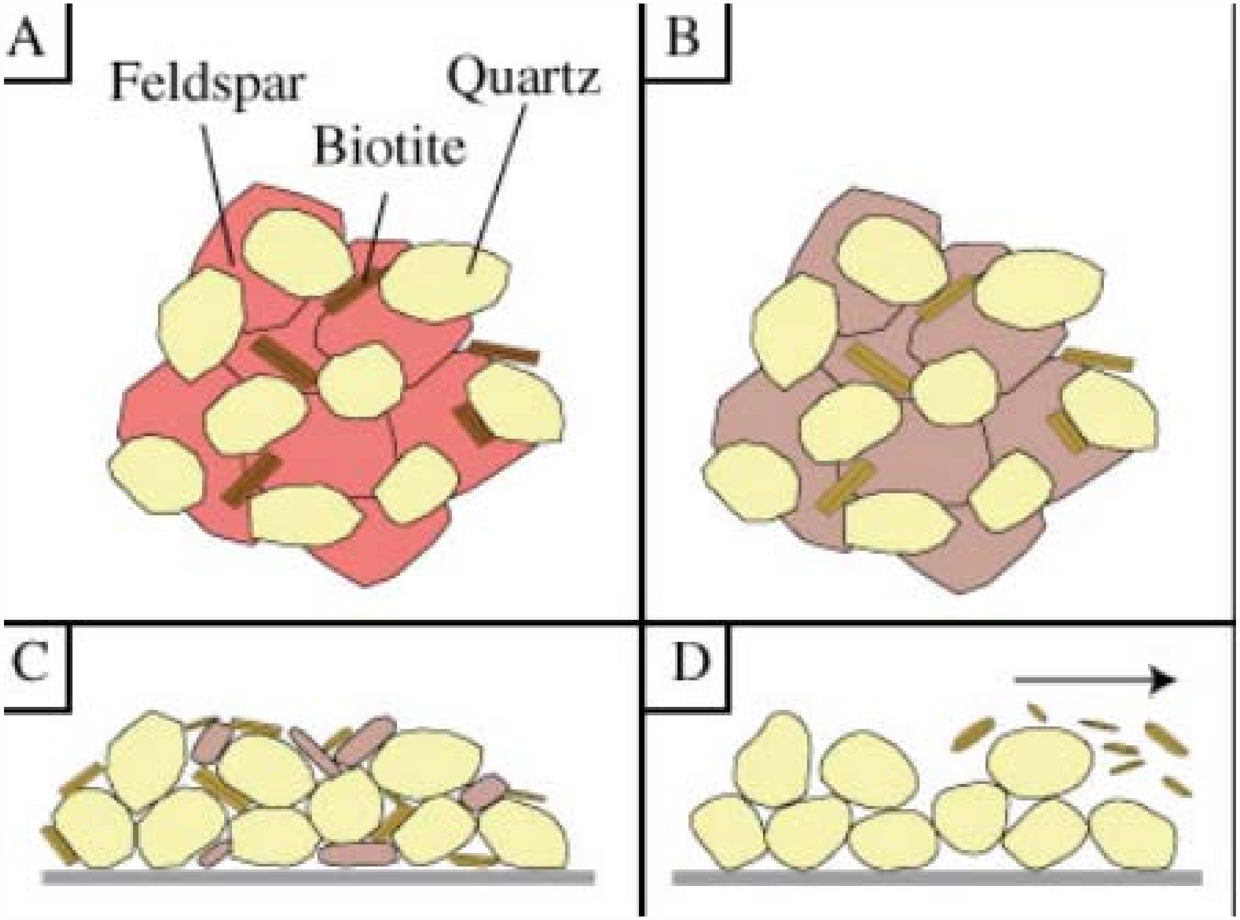


Single boulder, approximately 1 m on a side
Volume = 1 $m^3$
Surface area = 6 $m^2$

8 fragments, each approximately 0.5 m on a side
Volume = $(0.5)^3 \times 8 = 1\ m^3$
Surface area = 12 $m^2$


Incipient cracks form along crystal boundaries, and feldspar, biotite, and magnetite start to decay
Decay of feldspar, biotite, and magnetite progresses: as cracks open, rock weakens and is easily disintegrated
Feldspar
Biotite
Magnetite
Quartz

(a) Fresh granite
(b) Granite starting to weath
(c) Granite extensively weathered



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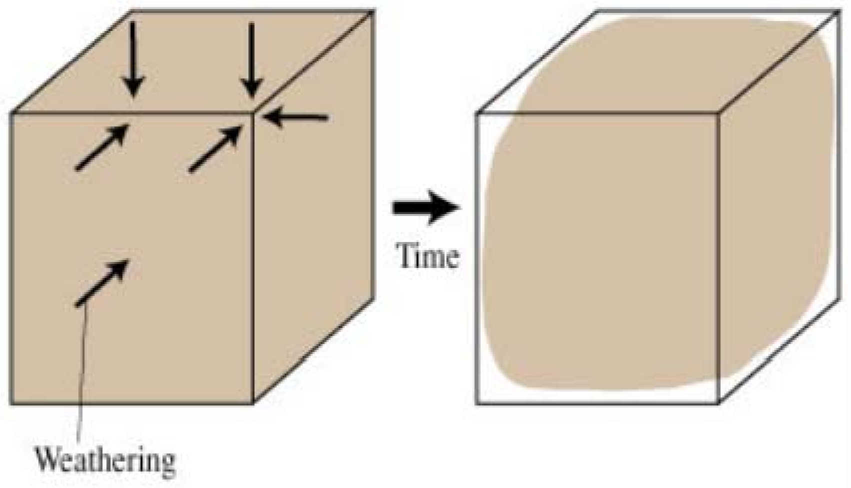

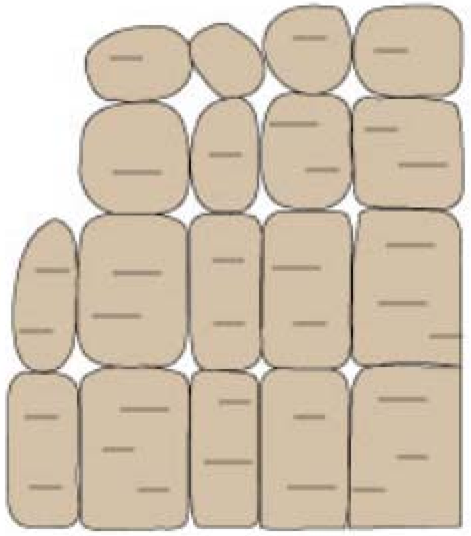

**Extensive weathering results in the development of rounded boulders**

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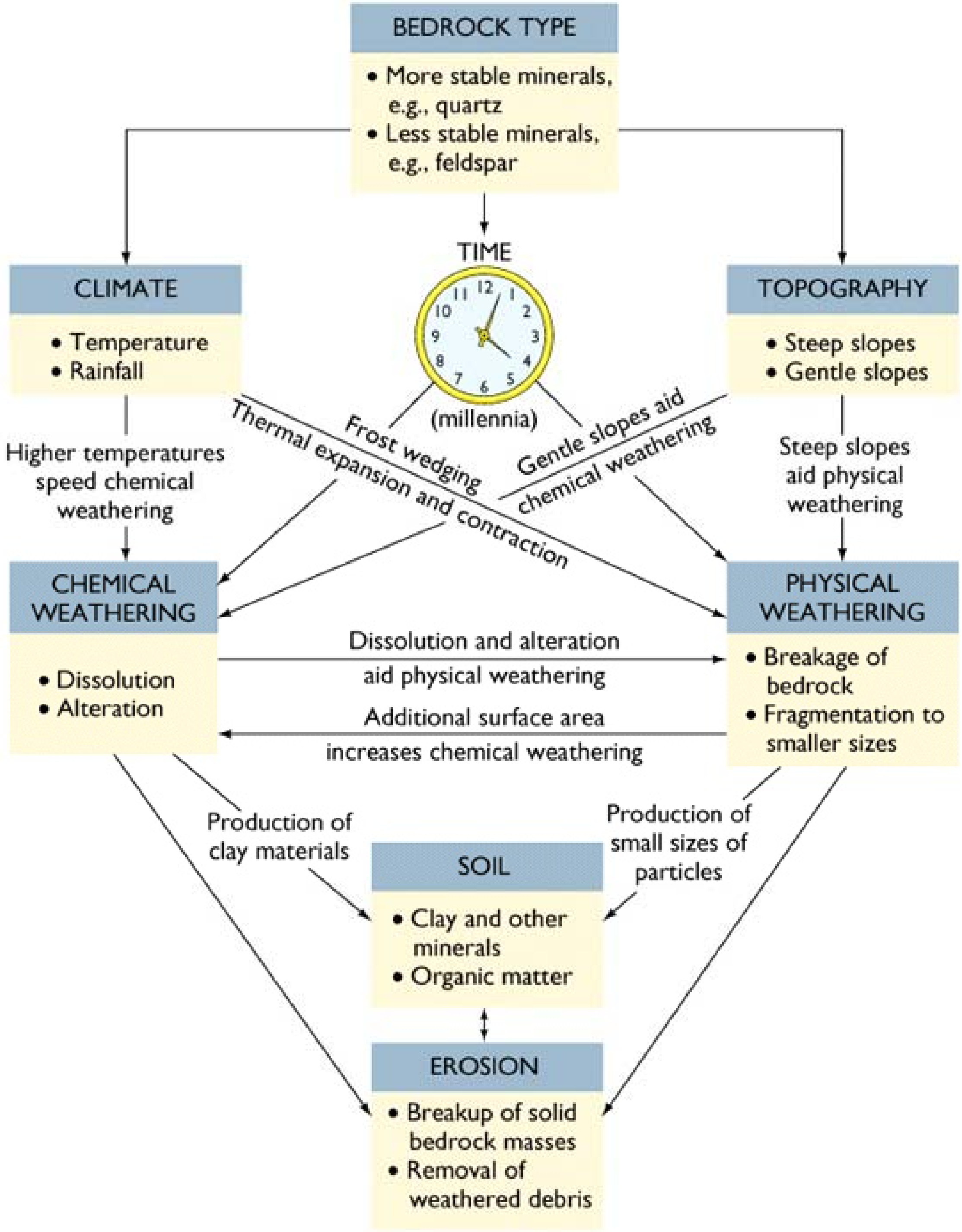

**BEDROCK TYPE**
- More stable minerals, e.g., quartz
- Less stable minerals, e.g., feldspar

**TIME**
(millennia)

**CLIMATE**
- Temperature
- Rainfall

**TOPOGRAPHY**
- Steep slopes
- Gentle slopes

Higher temperatures speed chemical weathering

Thermal expansion and contraction

Frost wedging

Gentle slopes aid chemical weathering

Steep slopes aid physical weathering

**CHEMICAL WEATHERING**
- Dissolution
- Alteration

**PHYSICAL WEATHERING**
- Breakage of bedrock
- Fragmentation to smaller sizes

Dissolution and alteration aid physical weathering

Additional surface area increases chemical weathering

Production of clay materials

Production of small sizes of particles

**SOIL**
- Clay and other minerals
- Organic matter

**EROSION**
- Breakup of solid bedrock masses
- Removal of weathered debris

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